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FIRE AND WATER IN SOUTHERN CALIFORNIA'S MOUNTAINS[1/]

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Fire protection is big business in the mountains of southern California. It has been big business for many years. Millions of dollars have been invested in equipment and in the construction of lookouts, roads, and communications to guard the mountains against fire, or make its control as effective as possible. The best skills, the most advanced machines, and the most vigorous research have been combined to keep fire detection and suppression adequate to the job. And each year nearly a million dollars are spent in suppressing those fires that do occur.

Why do we fight fires in southern California? Why is the public willing to make such large investments in protection? What have we at stake in these mountains that makes fire protection so important?

As you know, the dominant vegetation of the southern California mountains is chaparral. Chaparral occupies roughly 70 percent of the mountain land between San Luis Obispo and the Mexican border; the remaining 30 percent is made up of isolated forest stands at high elevations, and meadows and potreros lower down. Chaparral grows and remains on the mountains despite drought and despite fire. It grows in the winter and spring when rains provide water for its use. In the summer, when the soil becomes dry, it passes into a dormant state, and in this state it can survive long periods of drought. If fire burns it to the ground it is not destroyed. Some species sprout at the root-crown and thus re-form a cover from their burned stumps. Other species are killed by fire, but their seeds germinate under the stimulus of the fire's heat, and new plants grow to replace those that have been killed.

1/ Talk presented at meeting of the Southern California Association of Foresters and Fire Wardens, at Pasadena, April 23, 1951.

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If you subscribe to the philosophy that vegetative cover on the mountains is an essential element in the control of erosion, of floods, and of water supply, then you have reason to believe in the importance of fire protection in the mountains. If you consider the chaparral as the most easily maintained vegetative cover that can be held on these mountains, then you can see some justification for even high costs of fire prevention and fire suppression.

Let me refresh your memories about some of the consequences of chaparral fires in southern California. First, let's look at some examples of fire and flood.

In November 1933 seven square miles of chaparral burned in the mountains above the cities of Montrose and La Crescenta. On New Year's Day in 1934 this area was in the path of a severe storm which covered most of southern California. Although unburned watersheds nearby produced only normally high stream flow, the burned area loosed a flood that devastated several towns, brought death of 30 persons, damaged or destroyed 483 homes, and caused $5,000,000 worth of damage. More than 600,000 cubic yards of debris were scoured from the mountains and deposited in the valley. Boulders as large as kitchen stoves rode the thick mud flows and smashed all before them.

In July 1945 an airplane crashed into the chaparral in the headwaters of Santa Ana Canyon, east of San Bernardino. The fire it started burned 4,000 acres of brush and timber. Although this burn denuded only one twenty-fifth of the upper Santa Ana River watershed, the mud and rocks released from it during thunderstorms that autumn caused far-reaching damages. Debris-laden flows interrupted the operation of three hydroelectric plants that depend upon the flow of this stream. Irrigation schedules on 10,000 acres of citrus land between Riverside and San Bernardino were disrupted because silt clogged the furrows and water would not seep into the soil. Even beyond Riverside bacterial pollution of drinking water coming from this stream rose so high as to be a menace to health.

Last July we witnessed the most prompt fire-and-flood sequence of our experience. On July 4 a grain field on the Jackson Ranch, some 4 miles north of Yucaipa, caught fire from a harvesting machine. The flames spread rapidly to the hills above, and burned off about 630 acres of chaparral. Two days later, as the fire was being mopped-up, a severe thunderstorm struck the burn and the area surrounding it. Rain records obtained in three places around the burn showed that about 3/4 of an inch fell, some of it at rates of more than 2 inches per hour. Within a short time after the start of the rain, mud and boulders poured from the burned area in such quantities that roads below were blocked and bulldozers had to clear a way for removal of fire camp equipment. For nearly 2 miles below the burned hills, these mud flows did several thousand dollars worth of damage to road crossings and farm improvements.

During October and November we made a careful study of the burned canyons, of the debris flows, and of adjacent unburned canyons. We found that 6,725 cubic yards of mud and rock had been washed from one burned drainage of 211 acres. As usually expressed this indicates an erosion rate, for one storm, of over 20,000 cubic yards per square mile. But in and below adjacent drainages that had not burned there was ample evidence that no runoff or erosion had occurred.

I want to emphasize here that great floods can occur in southern California even though the mountain watersheds are long unburned. Most of you recall the floods of March 1938. The rains that caused these floods were among the heaviest and most prolonged of record in this area. Great damage was done in the valleys below mountain watersheds that had not been burned in many years and that had what we consider to be excellent vegetative cover. Our studies on the San Dimas Experimental Forest showed that during this storm there was almost no runoff over the surface of the ground. The record peaks of streamflow came after the soil mantle of our watersheds had filled with water. Then, with continued rain there was a rapid seepage of water underground from the hill soils into stream channels. It was this seepage water that swelled the streams and it was the cutting of stream banks and the gouging of channel gravels that produced the debris loads that did so much damage downstream.

I want to point out also that floods do not always follow fire in the southern California mountains. In 1932 the Matilija fire burned off 219,000 acres of mountain land in Los Padres National Forest. The next winter there was severe erosion on the burned slopes and great damage was done to reservoirs and other developments downstream. In 1948 the Wheeler Springs fire burned 26,500 acres east and south of the Matilija burn, but no floods and little erosion have been reported since that fire. The reason for the difference is to be found in the rainfall. After the Matilija burn, rainfall was heavy for several years. Since the Wheeler Springs burn, rains have been light and annual rainfall has been far below normal. Similar comparisons can be made in burned mountain areas in other parts of southern California.

Finally I want to point out that a burned watershed does not recover quickly. It takes years for the re-growing vegetation to regain its control over the eroding and runoff-producing action of heavy rains, and much of the soil material washed from burned hillsides into stream channels may be long delayed in reaching reservoirs and valley lands. A study recently completed by the Forest Experiment Station shows that erosion rates remain above normal for at least 8 years after watersheds have been denuded by fire, and that flood peaks of stream flow stay above normal for at least 20 years.

So much for floods. Now, what of the relation between fire and water supply? The water supply of most of southern California is closely dependent upon the health of the local mountain watersheds. Healthy watersheds give good water; burned watersheds can give muddy water. Mountain water is made available for human use in several ways. Some streams are provided with diversion works which spill water into canals leading to distant orchards and croplands. Dams span the mouths of some canyons so that the high flows

of winter and spring can be held in reserve for summer use. Spreading grounds occupy the outwash plains of other canyons. Stream water is led in ditches across these grounds so that it will sink into the porous gravels; from there it travels underground to add to the supply for wells in the valley.

All these water-handling works require protection. Siltation can destroy the storage capacity of reservoirs. Since their construction between 1920 and 1937, eight reservoirs in the Los Angeles River drainage have lost an average of one-quarter of their original storage. Debris-laden storm flows can wreck diversion works. Silt-laden water plugs the gravels of spreading grounds, preventing water from sinking into underground storage. Muddy flows cannot be used on croplands because they seal the irrigation furrows so that water cannot enter the soil.

Protection of water handling works is accomplished in two ways. Wherever possible they are equipped to by-pass flood flows which would cause them damage. This means wasted water: water carried downstream as directly as possible, and dumped into the sea. Prevention of waste requires protection of another kind: that accomplished by preserving an adequate cover of chaparral on the mountain watersheds. This kind of protection insures the long life of reservoirs and good regulation of stream flow.

I can give you an example of the effect that burning has upon water yield. Two typical chaparral watersheds lie in the mountains above Monrovia. Their waters flow into the north side of the San Gabriel Valley where they are diverted to irrigate many hundreds of acres of citrus, and to supply the domestic needs of several towns. Santa Anita Canyon, to the west, has an area of about 10.5 square miles; Fish Canyon, a short distance east, covers about 6.5 square miles. Stream flow from both canyons has been measured continuously since 1918.

In late August of 1924 the entire watershed of Fish Canyon was burned, but Santa Anita was untouched. Records of stream flow between 1918 and 1924 showed how the water yield of these watersheds compared before the fire. Similar records taken between 1924 and 1930 showed, by comparison, how the yield of Fish Canyon had changed.

The following interpretations of stream flow records obtained between 1918 and 1930 is based upon a series of technical papers on the subject which appeared between 1932 and 1934. The original analysis of the records was presented in 1932 by W. G. Hoyt and H. C. Troxell, of the U. S. Geological Survey.[1] Their conclusions and interpretations were challenged by W. C. Lowdermilk[2] of the U. S. Forest Service, and others,[3] in papers which appeared in 1933 and 1934. I believe that there is now general agreement with the interpretation that follows.

1/ Hoyt, W. G., and H. C. Troxell. Forests and Streamflow. Proceedings American Society Civil Engineers. 58:6. 1932.

2/ Lowdermilk, W. C. Forests and Streamflow: Discussion of the Hoyt-Troxell Report. Journal of Forestry: 31:296-307. 1933.

3/ Hoyt, W. G., and H. C. Troxell. Forests and Streamflow (with discussion). American Society Civil Engineers Paper No. 1858. 1934.

For several years after the fire Fish Canyon yielded more water in relation to the flow from Santa Anita, than it had before the fire. Burning, therefore, had clearly increased stream flow. If volume of flow alone were considered then it would have to be admitted that burning had been beneficial. But volume of stream flow is not the only criterion, nor is it even the most important one. The way in which water is delivered to the valley can be of far greater importance, and it is in this light that the results of burning must be considered.

More than 90 percent of the yearly yield of water from Fish Canyon is delivered to the valley during the winter and spring, when high stream flow is maintained by frequent rains. Before the fire almost all of this water could be used; only the peak flows from the heaviest storms had to be wasted. After the fire, however, the normal storm flows were turned into muddy flood waves. In this condition they were completely unusable. Some of them could be held within the stream channel and passed safely to the sea. But others were so violent that they jumped the stream banks and ran wild through the valley lands.

The summer flow of Fish Canyon was also increased by the fire. For several years after the burn summer stream flow was more than four times as great as normal. But summer flows from Fish and Santa Anita Canyons are mere trickles, accounting for less than 5 percent of the yearly stream flow. A four-fold increase in this usable water could hardly make up for the water lost in winter and spring floods, or for the damage which some of these floods had done to the land.

There remains one very important question: were the increased summer flows really the result of burning the chaparral? The soil under the chaparral on slopes is completely drained shortly after the end of the rainy season. We cannot therefore expect stream flow to be fed from this source during the summer. What, then, caused the measured increase in summer flow?

The answer to this question is found in the stream-bank vegetation: the alders, willows, and sycamores that live with their roots in the saturated channel gravels. During the dry season they survive by the use of water flowing underground. When fire removes them, as it did in Fish Canyon, this source of water loss is gone, nor does it return until the stream-bank vegetation is re-established. It was the destruction of this vegetation, not of the chaparral on the slopes, that must have caused the increase in Fish Canyon's summer flow.

And so the water-yield story is told. Fire in the chaparral can increase water yield. But this increase does not mean that more water will be available for human use. It means, rather, that more water may be wasted and that valley lands will be threatened by floods that can wipe out the very investments which receive sustenance from a safe, well-regulated water supply.

The relations I have just described between fire and water have, I hope, shown you why we in the Forest Service have been so vigorous in advocating and practicing fire control in the mountains. In fact, an understanding of these relations was one of the principal reasons for the establishment of national forests in southern California.

But as you know it is not only in the mountains that there has been activity in providing flood control and in working toward an adequate water supply. Work has been going on elsewhere as well. Years ago reservoirs were built in the mouths of many mountain canyons for both flood control and water conservation. More recently large dams, such as the Santa Fe and Hansen, were built to protect valley lands from floods. Lined channels and levees were built to carry flood waters safely to the sea or to divert them from where they might do damage. And for additional water southern California has tapped rivers hundreds of miles away.

In view of all these engineering works are we still justified in protecting our local mountains against fire? Is watershed protection still important in the headwaters when so much has been done in the valleys?

Let's look first at floods. What have engineers provided with their dams, lined channels and levees? They have provided, or are providing, sufficient storage space and channel space to take care of the greatest floods of water that are expected, even from burned watersheds, on the major streams of southern California.

But floods are not made of water alone. They are also made of mud, sand, gravel, boulders, and other debris. We have seen this material fill reservoirs and choke flood channels. Claims have been made that reservoirs can be cleaned by sluicing at a very low cost, although this has not yet been demonstrated as feasible on a large scale. But suppose we assume that some of the reservoir accumulations can be removed in this way. Then we find that the sluiced material will be moved into channels downstream that have very low gradients. There is no simple and inexpensive way to clear these channels, yet they must be kept clear or they will cease to be effective in carrying the high flows for which they are designed.

Suppose, though, that reservoirs can be cleaned and that channels can be cleared. Then the ultimate resting place for debris from the mountains is the Pacific Ocean. There is no room to dump the debris along stream courses, as nature used to do. That can no longer be done because the land along stream courses is all being used for homes and industries or will be in the not too distant future. So the mountain streams will pour their loads directly into the sea. But don't picture the whole Pacific Ocean as the resting place of these loads. The main resting places will be on or near the California shore. It is true that our beaches will receive a larger supply of sand than they get now and this would be good. But so also will harbors receive a larger supply of sand and mud and there it must be dredged to maintain clear space for shipping.

What about water? Local water supplies have for many years been inadequate to satisfy the needs of southern California. I have already mentioned the ways in which local water supplies are developed, and the wastage of water that is often caused by mountain fires. So valuable has water become that steps are now being taken to treat sewage in the Los Angeles area so as to reclaim from it large quantities of water that are normally wasted.

But in its rapid development southern California has also looked beyond its mountains for water. Los Angeles reached out 300 miles to the Owens River for additional water. The Metropolitan Water District tapped the Colorado River and brought water 300 miles to supply the Los Angeles area and cities as far south as San Diego. At the present time only about 1/8th of the 1,200,000 acre feet of water that will ultimately be available each year from the Colorado is being used, so there is still water to spare, at a price, from this source. And in case all these water sources become insufficient to supply future needs the State Division of Water Resources has surveyed a route by which water can be carried to southern California from the Sacramento River, and even from the Klamath River near the Oregon line.

Considering all the engineering developments that are providing, or will provide, flood protection and water for southern California, do we need to worry any longer about the source areas of local floods and local water supply? Can we justify the costly job of protecting the watersheds of southern California? Is fire control needed in the mountains?

I think that I can answer these questions by referring to three words: area, feasibility, and time.

First, area. Adequate flood protection is being provided only for major centers of development: large cities in the valleys and along the coastal plain, important rail centers, and zones of industrial development. Communities built in or near mountain canyons, and most areas along the mountain fronts away from the main river courses are not protected adequately from floods that can come from burned watersheds above them.

Second, feasibility. It has not yet been demonstrated or proven that the storage capacity of silted reservoirs can be restored. Every acre-foot of debris in a reservoir reduces its capacity to control floods and to store water for later use. Nor has it been demonstrated that channels and levees can be maintained as effective flood control structures when their capacity is reduced by debris-laden water.

Third, time. Flood control works in the valleys are not yet complete. For some time to come those lands that will one day receive even some protection from dams and floodways will be vitally in need of the extra protection afforded by fire control in the mountains above. Furthermore, adequate flood control can only last as long as structures remain in usable condition. In most cases reservoirs are planned to have a useful life of 50 years. Reservoir sites are scarce in southern California. The choice is between adequate protection of reservoir storage now and in

the future, and ineffective reservoirs in a half-century. As for water supply, at present a good deal more than half the water used in southern California is yielded from the local mountains. And even though imported water will eventually become more plentiful, and will be used more widely than it is at present, the local water will still be in demand, for it is the less expensive, by far, of the two.

All these considerations lead me to only one conclusion: that for as far as we can see into the future, southern California will have to protect its mountains against fire. A large part of its present development has depended upon protection of the mountains in order to minimize the catastrophe of floods, and to insure the greatest yield of good water. I can see no reason why mountain fire protection should be less important in the future than it has been in the past.